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An Evaluation of Turfgrass Species and Varieties: The Bentgrasses

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INTRODUCTION

The genus *Agrostis* comprises approximately 125 species occurring in a climatic range that extends from the sub-temperate to sub-arctic and includes a global circum-boreal distribution. *Agrostis* species can also be found in the high altitudes of both the tropics and subtropics. The genus *Agrostis* includes the pasture grass redtop, and the bentgrasses, a title applied to all of the constituent species used as turfgrasses. The growth habit of genus members range from bunch types exhibiting limited stoloniferous elongation to recumbent types exhibiting extensive stolon growth. Among the commonly used cool-season turfgrasses, the bentgrasses are the most tolerant of close and frequent mowing, primarily due to this prostrate growth habit. With intensive management efforts, the bentgrasses may tolerate mowing up to three times daily at diminutive heights of 0.1 in. The bentgrasses form dense, fine to very fine textured, high-quality carpet-like turf, but require the highest standards of continuous maintenance. Because of this tolerance to close and frequent mowing, the bentgrasses are used primarily on golf course putting green and tee surfaces, bowling and croquet greens, grass tennis courts, and fine-quality garden areas that all require intense management and constant attention.

Some *Agrostis* species are annuals, but all of those used for turf are perennial. It is this perennial nature and strongly stoloniferous habit that predisposes bentgrasses to a weedy habit and in some habitats, the bentgrasses may become invasive to the point of displacing native or introduced species. This trait suggests that turfgrass managers monitor the off-site movement of these grasses in the hopes that appropriate stewardship will mitigate or prevent entirely any invasive displacement. Such stewardship will become increasingly important as herbicide-resistant cultivars, such as Round-Up Ready Penncross, are released to general unsupervised use.

The *Agrostis* species are best adapted to cool to cold, humid and transitional climatic regions. The perennial members exhibit excellent cold tolerance, superior ice and snow tolerance, but spring greenup may be slower than that noted for Kentucky bluegrass (*Poa pratensis*). Among the cool-season turfgrasses, the bentgrasses are the most tolerant of short-term inundation and flooding, but are relatively intolerant of drought or high-temperature stress. The bentgrasses perform best on moist, fertile moderately textured soils with a pH of 5.5 to 6.5. The morphological features common to these species include adaxial leaf edge ridging, rolled vernation and single-floret spikelets. The thin papery ligule may be minute to nearly indistinguishable and auricles are absent.

The four species employed as turfgrasses include creeping bentgrass (*A. palustris* Huds., *A. stolonifera* L.), colonial bentgrass (*A. tenuis, A. capillaris*), velvet bentgrass (*A. canina*), and, more rarely, redtop (*A. alba, A. gigantea*). The objective of this four-year study was to evaluate the performance of 29 commercially available bentgrass cultivars under the environmental conditions of central Maine.

The Creeping Bentgrasses

Description

Creeping bentgrass (*A. palustris* Huds., *A. stolonifera* L.) is a moderately fine-textured stoloniferous species originating in Urasia and is the most widely used cool-season grass for golf and bowling greens. Its common name is derived from its vigorous creeping stolons, which develop at the soil surface and initiate both new roots and shoots at stolon nodes.

In the early part of the last century, golf greens were seeded and overseeded with mixtures containing small percentages of creeping bentgrass, most commonly a mixture still known and available as "South German Bent." During the 1920s and 1930s, valuable creeping bentgrass clones were identified and preserved through efforts of the U.S. Department of Agriculture and the U.S. Golf Association's Green Section. Some of these are still regarded as valuable germplasm, and serve as genetic sources of disease and insect resistance, cold and heat tolerance, and horizontal growth habits.

Creeping bentgrass exhibits rolled vernation with developing leaves rolled entirely within the sheath. It has a membranous ligule that ranges from 0.6 to 3 mm in length and may be finely toothed or entire. There are no auricles and the collar may be narrow to broad. Leaf blades are flat, triangular, 2 to 3 mm wide at the base, and ridged on the adaxial (lower) surface. The abaxial (upper) leaf surface is smooth with scaly margins. The inflorescence, when visible, is a contracted panicle bearing numerous spikelets and is pale to purple in coloration. Growth habits range from compact for those cultivars with fine texture to open and somewhat upright to those cultivars classed as coarse. Leaf color ranges from light yellow-green or apple green to both dark green or blue-green with typical cold or winter colors in the dark blue to purple range. The stoloniferous habit enables the creeping bentgrasses to spread rapidly, producing daughter plants at stolon nodes. The fibrous root system is dense, but rather shallow in depth. Creeping bentgrasses are relatively intolerant of compacted and compressed soils. Hence, areas typi-

cally receiving high traffic, such as putting greens, are often built on root zone mixes amended with fine particle sands to reduce the rate of compaction and improve drainage. Creeping bentgrasses also require frequent, annual or semi-annual manual efforts to relieve compaction. These include aerification with or without core removal, deep coring, spiking, and frequent top dressing.

Creeping bentgrasses are normally propagated by seed with seeding rates of 1.0 lb per thousand square feet used in cool climates and 1.25 to 1.35 lbs per 1000 ft^2 used in transition climates.

Adaptation and use

Creeping bentgrass is a long-lived perennial that exhibits a vast native adaptation. Creeping bentgrass is not recommended for casual use in home lawns, sports fields, cemeteries, or airports. Constant care is required to maintain its shallow root system and to control its rapid growth rate and aggressive spreading habit.

It is very tolerant of extreme cold, or inconsistently cold temperatures, but exhibits only fair heat tolerance. While creeping bentgrass may persist during the heat of mid-summer, shoot growth is seriously impaired and death of the root system may occur. Direct high-temperature kill and drought stress often plague the high-maintenance use of this grass. Frequent irrigation and syringing help offset these difficulties, but may in turn lead to increased disease susceptibilities. Year-long disease and insect challenges accompanied by spring and autumn weed infestations often require the extensive use of both manual and chemical control efforts.

Despite its tolerance of cool-season flooding, proper drainage is essential during periods of elevated soil temperatures. Creeping bentgrass tolerates partial shade, but performs best in full sun. The wear and traffic tolerance is poor in comparison to other turfgrasses, but its recuperative potential is high, and this accounts for its ability to survive and rebound after the imposition of championship or tournament conditions.

This bentgrass species tolerates a fairly wide range of soil types, but is best adapted to fertile, fine-textured soil of moderate to low acidity (pH 5.5 to 6.5) and to those with moderate water-holding capacity accompanied by excellent internal drainage. Of the cool-season turfgrasses, it is the most tolerant of saline conditions. Several cultivars have been selected from just such environments; the cultivar Seaside is one example of this.

Its tolerance of temporary or permanent soil compaction is poor, and this grass requires frequent manual efforts to relieve compacted soil. Recent advances in compaction mitigation include the deep injection of small streams of water (Hydroject), semi-annual or annual deep tine aerification, deep and shallow coring, spiking, and the use of spike rollers on mowing machines, and frequent top dressing. Attention to compaction control will need to be made no less than monthly if championship conditions are part of an annual cycle of golf course maintenance.

Creeping bentgrass is the principal cool-season species used to provide high-quality golf course putting greens, closely mown tees and fairways, and other high maintenance sports uses. Its aggressive growth habit will often overpower more upright grasses, and it is seldom used in polystands with Kentucky bluegrass, perennial ryegrass, or fine leaf fescues. It is occasionally used for overseeding dormant warm-season grasses such as bermudagrass, but when so used, it constitutes a small percentage in mixtures containing principally colonial bentgrass and rough bluegrass (*Poa trivialis* L.).

Cultural requirements for use as turf

Creeping bentgrass is usually mown to heights ranging from 0.1 to 0.5 in. (2.5–13 mm). Putting greens are mown daily at 5 to 7 mm to ensure smooth even putting quality. Creeping bentgrass may be mown twice daily in two directions for very short periods of time in order to satisfy championship requirements. At higher heights of cut, the stoloniferous growth habit may result in excessive thatch formation, excessive grain, scalping, and a subsequent decline in turfgrass quality. Thatch formation is also dependent upon cultivar selection, with some cultivars able to form excessive thatch when mown at 2.5 mm. Thatching rate and depth can be controlled by manual means that include frequent light topdressing, brushing, the use of Willey rollers, and occasional spiking. Shallow vertical mowing and brushing are also used to control and minimize the formation of grain or the linear and surficial arrangement of visible stolons. Spiking or the use of star blades will promote juvenile shoot development and rooting at the nodes as a means of enhancing recuperative potential. Creeping bentgrass has a nitrogen requirement of 0.8 to 1.4 lb per 1000 ft^2 per month of growing season for greens and 0.5 to 1.0 lb per 1000 ft^2 on higher cut turfs.

When managed as putting green turf, creeping bentgrass normally requires supplemental irrigation, especially when grown on blended sand-based root zones. Delaying the onset of irrigation in the spring will usually ensure a deeper-rooted turf, but the demands of summer play and environmental conditions will usually force the initiation of irrigation by early to mid-June in Maine. Syringing, or superficial water applied as a cooling medium is usually only required

in mid-summer with the advent of temperatures in excess of 85ºF.

The Colonial Bentgrasses

Description

Colonial bentgrass (*A. tenuis, A. capillaris*) is a fine-textured grass that originated in Europe and has become adapted to the cool, humid regions. It has been naturalized in the Pacific Northwest, New England, New Zealand, Great Britain, and Maritime Canada. Its growth habit ranges from bunch to weakly spreading types with short stolons and occasional rhizomes. It is generally less aggressive than creeping bentgrass, but may persist for much longer. The grass has been variously named Browntop, New Zealand Bent, Prince Edward and Rhode Island Bent, depending upon the location of naturalization and seed production.

Colonial bentgrass exhibits rolled vernation with a truncate membranous ligule that ranges from 0.3 to 1.2 mm in length. It lacks auricles, but has a narrow to medium broad oblique collar. The leaf blade is flat, triangular, 1 to 3 mm wide, ridged on the adaxial, but smooth on the abaxial surface, and bearing an acuminate apex. Stems are slender and erect with weak, short stolons or rhizomes, or in some cultivars, a bunch-type growth habit. This species bears short spikelets in an open panicle inflorescence.

Colonial bentgrass forms an upright dense fine-textured turf when properly managed. Its stems and leaves are delicate to fine in texture and subject to extensive wear and traffic damage. Its short internodes allow for close mowing, but variably close or infrequent mowing may allow the grass to "crown-up," that is, to produce an elevated crown with short elevated stolons. Such structures are subject to rapid drought stress, frequent disease challenges, and mow poorly. They also negatively affect the game of golf by providing a surface that rolls erratically. Infrequent fertilizer application or the application of calcium-rich fertilizers may also induce this elevated crown structure. Grain-reducing strategies such as spiking, star blades, and brushing will help minimize the development of these aerial crowns.

Off-types are likely to appear as the colonial bentgrass turf matures due to the heterogeneity of most colonial bentgrass cultivars. This heterogeneity often causes a decline in overall turf uniformity. Colonial bentgrass leaf color ranges from yellow-green to medium dark green, and its winter coloration is normally dark purple. The root system is shallow and fibrous and decidedly annual in nature. It has a weak creeping habit since stolons are short, but its aerial crowns may root wherever they make soil contact. It is moderately invasive and capable of displacing native grasses and wildflowers. To avoid invasive displacement, care must be used in disposing of clippings and corings. Colonial bentgrass is propagated from seed and more rarely by stolons or crowns and its establishment rate is good. Its poor wear and traffic tolerance is accompanied by marginal recuperative potentials, and it suffers under championship or tournament preparation.

Adaptation and use

Colonial bentgrass is a long-lived perennial utilized throughout the world's cool humid regions. It has excellent cold-temperature tolerance, as well as excellent snow and ice and cool-season flooding tolerances. It is intolerant of flooding when soil temperatures are elevated. Colonial bentgrass will tolerate a wide range of soil conditions, but does best on moist, fertile fine-textured soil with a pH range of 5.5 to 6.5. It can utilize nitrogen at low pH and persists in acidic and boggy soils. It is slow to green-up in the spring and exhibits poor tolerance to heat and water stress. It may be subject to direct high-temperature kill when temperatures exceed 95ºF in full sun. The grass exhibits moderate shade tolerance and may persist for decades in dappled shade or open-spaced tree conditions. Colonial bentgrass is normally used in polystands with other cool-season turfgrasses on closely mown or damp fairways, tees, and high-quality lawns. It is aggressive and eventually will dominate when seeded in mixtures with erect cool-season grasses such as Kentucky bluegrass or fine fescue. Colonial bentgrass is often used to overseed warm-season dormant grasses, but finds infrequent use on golf greens as a monostand in cool climates.

Cultural requirements for use as turf

Colonial bentgrass requires a relatively high level of cultural intensity to achieve a quality turf. Mowing heights range from 0.3 to 0.8 in. with excessive thatch build-up associated with higher cutting heights. Mowing frequencies may be once daily, but colonial bentgrass is relatively intolerant of twice daily mowing, brushing, or other methods of tournament preparation. Thatching and crown elevation may be relieved by frequent shallow top dressings if the application can be made with minimal injury to the turf. Colonial bentgrass requires frequent irrigation during periods of drought stress or elevated soil temperatures and is prone to form hydrophobic zones in fine-textured soils. Colonial bentgrass responds well to the use of water or Hydroject aerification and the use of surfactants to reduce hydrophobicity. Colonial bentgrass requires 1 to 6 lb of nitrogen per 1000 ft^2 per year, but will prefer this applied in intervals

of less than three weeks. Colonial bentgrass is very susceptible to disease and insect predation and is relatively intolerant of modern herbicides. Colonial bentgrass may suffer from nematode depredation in warm climates and both aerial and rhizosphere structures may be damaged by nematode feeding.

Velvet Bentgrass

Velvet bentgrass (*A. canina* L.) is a native of Europe, which has become naturalized in New England and Maritime Canada. It is the finest textured cool-season grass available today with soft needle-like leaves and a stoloniferous habit. When grown in temperate oceanic climates with meticulous care, it is considered by many to produce the most beautiful turf with the finest texture of all cool- or warm-season grasses. While less aggressive than creeping bentgrass, its season-long ability to produce stolons gives it a creeping habit that may border on invasive. This grass exhibits excellent uniformity and is very slow to demonstrate segregation by color or leaf width. There are only a few named cultivars available, but there have been several biotypes named for the region of adaptation; i.e., the Lake Sunapee Velvet, the Vesper Velvet.

Description

Velvet bentgrass is characterized by rolled vernation, a broad collar, and a pointed membranous ligule ranging from 0.4 to 0.8 mm in length. Leaf blades unroll to lie flat, but are less than 1 mm wide with scaly margins. The blades are slightly ridged on the adaxial side and smooth on the abaxial side. The inflorescence is a softly spreading reddish panicle bearing numerous tiny, nearly round seeds. Velvet bentgrass leaf color is uniformly the darkest green of all cool-season turfgrasses, but progresses to purple with the onset of winter. Velvet is the bentgrass that exhibits the most rapid green-up in the spring when drought stress is not an issue. Shoot growth of this bentgrass is rather slow, but it has an excellent root growth rate. In Maritime climates, the root system is quite perennial, but exhibits annual die-back when subject to inland summer temperatures. Since the rate of root and shoot decomposition is quite slow, thatch can build up in a very short time. Velvet bentgrass does not exhibit the aerial crowning of colonial bentgrasses, but when disturbed, velvet crowns will root wherever they come in contact with the soil. This grass is normally propagated by seed, crowns, and stolons, and occasionally but uniquely, by all three. Its establishment rate is slow and its recuperative potential is considered poor.

Adaptation and use

Velvet bentgrass is remarkably tolerant of acidic, infertile soil conditions, but prefers coarse-textured, well-drained soil with a pH of 5.0 to 6.0. It is not adapted to poorly aerated, imperfectly drained soils, but responds well to elevated levels of organic matter in soils. It performs best on native soils and is poorly adapted to the diurnal drought stress that accompanies artificially constructed root zone mixes. Velvet bentgrass demonstrates much more shade tolerance than most other turfgrasses and is often mixed with slender creeping red fescue for superior shade performance. Its use is restricted to cool-temperate climates, but it prefers an oceanic orientation. It is intolerant of conditions of high humidity and excess afternoon temperature stress and tends to be disease prone when grown under such conditions. It is uniquely suited to those areas with on-shore breezes that moderate temperatures and minimize their fluctuations. Velvet bentgrass has good high temperature tolerance, excellent low-temperature tolerance, but is intolerant of flooding during the growing season. In winter, it will tolerate shallow layers of ice, but suffers from wind desiccation when unprotected by snow.

Velvet bentgrass produces the highest quality turf possible under close, frequent mowing at 1.0 to 3.0 mm. Velvet bentgrass will tolerate occasional double mowing for tournament preparation, but its poor recuperative potential will limit the extremes of management to spring and autumn conditions. Velvet bentgrass tends to produce thatch under any mowing regime, but responds well to frequent but very shallow top dressings. Leaf and surface damage commonly associated with top dressing application should be minimized by employing mixes of a rather fine particle size. This grass also responds favorably to the inclusion of organic matter in the top dressing mix.

Velvet bentgrass produces the best possible turf with applications of 1.5 to 3 lbs of nitrogen per 1000 ft^2 annually, especially when applications are made in less than 0.20-lb increments at two- to three-week intervals. In summer, this grass responds well to supplemental irrigation, which is usually required on a near-daily basis. Velvet bentgrass is intolerant of soil hydrophobicity, but is often subject to damage when high rates of surfactants are used to overcome this condition. Its relatively poor recuperative potential limits the extent of major renovation efforts, and deep tining, core aerification, slicing, and star blades may all prove too aggressive for use with this grass. Whenever possible, managers should limit these activities to early spring or mid-autumn on alternate year schedules.

Velvet bentgrass is susceptible to iron chlorosis and to a very different group of diseases from other bentgrasses. Its low fertility requirements and its relative intolerance of high fertility levels can limit is recovery from disease or insect predation, mechanical procedure injury, and excessive wear. Velvet bentgrass is intolerant of machine traffic and care should be used to choose mowing equipment of the lowest possible weight. Efforts should be made to minimize sharp turns, double cuts, clean-up laps, and other mechanical stresses. Velvet bentgrass is uniquely suited to privately owned and operated courses with a restricted number of golfers wearing soft spike shoes and exhibiting considerable care.

Redtop (*A. alba, A. gigantea*)

Redtop is a coarse-textured rhizomatous species found primarily in pasture mixes. It can still be found as a component in cool-season grass mixes designed for low-quality lawns, airports, municipal parks, parking areas, cemeteries, and low-maintenance ditch banks and roadside verges. A native of Europe, it is rarely evaluated in this country and was not included in this test.

MATERIALS AND METHODS

On June 15,1999, the National Turfgrass Evaluation Program (NTEP) bentgrass test was seeded at the Turfgrass Experimental Section of the Littlefield Ornamentals Trial Garden on the University of Maine campus in Orono. The prepared soil was a well-drained Marlowe fine sandy loam, which had been amended with 60 lb of lime per 1000 ft^2 and 20 lb of 10-10-10 per 1000 ft^2 as per Maine Soil Testing Service recommendations. Seeding was accomplished by using a 5x3-ft plywood box to prevent seed from drifting into adjacent plots and then raking in to ensure soil-seed contact. Supplemental moisture was supplied through an in-ground irrigation system controlled by a Toro computer. The test consisted of 29 varieties, which were replicated three times.

This study was conducted in a shade-free area on a maintenance fertility program of 1.0 lb N per 1000 ft^2 per month of growing season using a commercial 20-5-15 fertilizer with 50% N provided as slow-release sulfur-coated urea source.

Mowing was initiated in July 1999 using a John Deere Model 220 A greens mower set at a mowing height of 0.25 in., which was maintained throughout the growing season. Clippings were removed, but plots were not de-thatched or aerified during the course of the study. There was evidence of some encroachment into adjacent plots by some of the more aggressive varieties.

Visual turf quality and disease ratings were made on a monthly basis throughout the growing season. The quality ranking scale used was 1 = no living turf, and 9 = ideal turf. Yearly data were compiled and sent to the NTEP office in Beltsville, MD, for statistical analyses. These data are presented for each year of the study and have also been combined for the four years of the study. Means have been separated and arrayed for each of the factors evaluated.

RESULTS AND DISCUSSION

In general, all the bentgrass cultivars preformed well to very well in this mid-Maine location. Several of these newly released bentgrass cultivars, especially the velvet bentgrasses, showed promise for use at high-intensity sites in Maine and New England. Increased percentage of germination along with a decreased rate of germination, significantly finer leaf texture, improved color, and a more rapid recovery following disease or insect attack are some of the advantages the turf manager can expect from these new bentgrasses. The results for the four years of the 1999 NTEP Bentgrass Trial are included in Tables 1–5.

1999

With a delayed seeding made in June of 1999, all of the bentgrasses represented were provided with the opportunity to germinate in warm, moist soils accompanied by the high light intensity that occurred during long spring days. Very rapid germination was observed with nearly half of the cultivars in this test (Table 1). Data taken two weeks after seeding indicate that four cultivars had spread to cover 95% of the plot area, 10 had spread to cover greater than 90% while 11 had spread to 85% of the plot area. Only two cultivars, SR7200 and Imperial, lagged behind in the rate of spread. Vesper, AST-CRB-1, ISI AP-5, and L-93 all demonstrated rapid germination and rapid spread to permit complete plot coverage in less than three weeks. Crenshaw, SYN 96-3, BAR CB 8US3, Bengal, PENN G-6, PENN A-2, SRX 1BPAA, Providence, SR 1119, and PICK CB13-94 were nearly as rapid in germination and covered the plot completely in four weeks. The velvet bentgrasses SR 7200 and Imperial were slow to germinate and to cover the plot area, requiring nearly eight weeks before soil was no longer visible.

Overall turf quality ranged from fair to very good during the first year of establishment. Seven grasses with significantly improved quality scores above 6.9 included SRX INJH, Crenshaw, Brighton, Century, SR 7200, AST-CRB-1, and Vesper. Of these, Vesper averaged quality scores of 7.6 and appeared

Table 1. Turfgrass quality, genetic color, percent cover, and leaf spot ratings for bentgrass varieties seeded in May 1999 at the University of Maine. Means are the average of monthly ratings made during the 1999 growing season.

Variety	Quality[1]	Genetic Color[2]	Leaf Texture[3]	% Cover
1. VESPER	7.6	6.0	9.0	95
2. ABT-CRB-1	7.3	7.3	6.7	95
3. SR 7200	7.2	5.7	9.0	80
4. CENTURY	7.0	8.0	5.3	88
5. BRIGHTON	7.0	7.7	4.0	87
6. CRENSHAW	6.9	8.0	6.0	93
7. SRX 1NJH	6.9	7.7	4.7	88
8. SYN 96-3	6.8	7.7	5.7	92
9. PENN A-1	6.8	7.7	5.0	87
10. BAR CB 8US3	6.7	7.7	4.3	90
11. SYN 96-1	6.7	7.3	3.7	87
12. BENGAL	6.7	8.0	5.0	92
13. PENN G-1	6.7	7.3	5.3	85
14. ISI AP-5	6.7	7.7	5.3	95
15. IMPERIAL	6.6	7.3	5.3	83
16. PENNLINKS	6.6	8.3	5.0	88
17. PST-A2E	6.6	7.3	5.7	88
18. PENN A-4	6.6	6.7	4.7	88
19. PENN G-6	6.6	7.3	5.0	93
20. PENN A-2	6.5	7.7	4.7	93
21. SRX 1BPAA	6.5	8.0	4.0	93
22. L-93	6.5	7.3	4.0	95
23. PROVIDENCE	6.5	7.0	4.3	93
24. SYN 96-2	6.5	7.7	5.0	87
25. SR 1119	6.5	7.3	4.7	92
26. BAVARIA	6.4	5.3	9.0	88
27. PICK CB 13-94	6.4	8.0	4.3	92
28. BACKSPIN	6.3	6.3	4.7	90
29. PENNCROSS	6.3	7.7	5.7	90

[1]The first seven varieties did not differ significantly in turf quality.
[2]Varieties with genetic color ratings of 7.7 or higher were not significantly different.
[3]Leaf texture ratings of 9.0 were significantly finer than others.

remarkably better than other bentgrasses, retaining full plot coverage and demonstrating tolerance of uneven mowing and of minor pest attacks. Twenty-two grasses were not significantly different despite nearly one full point of difference in overall turfgrass quality scores. Less than acceptable leaf texture and moderate color were factors that contributed to the lower quality scores seen here. Of these, seven grasses had acceptable quality scores of 6.7 or more, including SYN 96-3, PENN A-1, Bar CB 8US3, Syn 96-1, Bengal, PENN G-1, and ISI AP-5. The industry standard, Penncross, preformed poorly during this first season or establishment year.

The highest average genetic color score reported was 8.3 for Pennlinks. Genetic color scores ranged from highs of 8.0 observed for Century, Crenshaw, Bengal, SRX 1BPAA, and PICK CB 13-94 to a low of 5.3 for Bavaria. Grasses whose color averaged higher than 7.7 were considered excellent and were significantly different from those with lower scores. The improvement in color scores and the gradual darkening or "blueing" in bentgrass color reflects a modern trend in turfgrass breeding. This attribute will allow the architect planning a golf course or the turf manager to permit the putting surfaces to be distinguished visually from other playing areas.

Leaf texture or leaf blade width was scored on a scale of 1 to 10, with 10 being very thin and with 1 being very wide. The majority of the bentgrass cultivars in this test showed moderate to extremely narrow leaf texture. The two velvet bentgrasses Vesper and SR 7200 as well as Barvaria were the most narrow, with scores of 9.0. This is a significant improvement over the wider colonial and creeping bent leaf types seen in the other cultivars. ABT-CRB-1 was significantly different from the others with a score of 6.7, while the remaining grasses were wide bladed and coarse in texture. The best of these include Crenshaw, SYN96-3, and PST-A2E.

2000

The winter of 1999–2000 was harsh and often free from snow cover. Mid-winter turf color was dark blue to purple with little difference observed between cultivars. Pink snow mold occurred despite prophylatic treatment, and the bentgrass cultivars differed in the time required to recover from this disease and other winter injuries.

Percentage of fall cover ranged from a high of 93% for Vesper, 92% for PST-A2E and Bengal, and 90% for SR 7000, SRX 1NJH, ABT-CRB-1 (Table 2). The majority of the cultivars in this test had fall cover scores that ranged from 79% to 88%. Five cultivars demonstrated poorer percent cover scores of 77% to 78%.

Turf quality in the spring of 2000 was significantly higher than that seen during the establishment year. Overall quality for Vesper was nearly perfect at 8.7, and SR 7000 was exceptional at 8.4. Each of these grasses averaged at least one of three replicates that scored at 9.0 for every observation date during the 2000 growing season. The exceptionally high quality noted for these two velvet bentgrass cultivars can be attributed, in part, to the milder climate associated with our proximity to the Maine coast. Adequate irrigation and cool nights without the stress of Pythium blight helped ensure that these grasses would develop quality scores consistently higher than that seen for any of the other bentgrasses located at the Littlefield Garden.

Four grasses, SRX 1NJH, SRX 1BPAA, PST-A2E, and ABT-CRB-1, had quality scores that ranged from a low of 7.0 to 7.3 for this seasonally dependent variable. An average score of 7.0 is excellent and indicates the grass could be used successfully throughout New England.

The majority of the grasses in this test averaged quality scores that ranged from 6.1 to 6.9 with greater quality seen in Bengal and SYN 96-3 and poorer quality seen in Penncross, Providence, and BAR CB 8US3. Two grasses, Pennlinks and Bavaria, were extremely susceptible to crowning up, brown patch, and summer stresses associated with severe leaf spot and brown patch infections. Since these disease pressures are much less severe at this Orono, ME, location than those encountered in interior New England or in the transition zone, these cultivars will probably not be used in highly managed turf situations. They may demonstrate greater stress tolerance when mown at higher heights on step-cut fairway and roughs. Otherwise, they may find their best niche in shade mixtures seeded in dappled light conditions under tree and shrub canopies.

In 2000, genetic color was greatly improved and much more consistent than during the first season. Extremely dark and deep coloration was noted for Vesper, SR 72000, and SRX 1BPAA, each of which recorded perfect 9.0 color scores for every monthly evaluation date in 2000. At no time and under no conditions did these grasses appear off-color, faded, drought stressed, or impeded in any way. This exceptional dark coloration was visible from greater than 100 yards away and served as a benchmark against which to evaluate other grasses. Two grasses, SRX 1NJH and ISI AP-5, demonstrated color that was nearly as dramatic, averaging 8.7 across all evaluation dates. Three grasses, ABT-CRB-1, PENN G-1, and PENN A-4, averaged 8.0 color scores; these are significantly better than the remaining bentgrasses in the test. Sixteen of these grasses averaged a very respectable 7.0 or above while only five of them fell below a 6.9. Intense leaf spot and brown patch symptoms accompanied by susceptibilities to green cutworm caused Bavaria, Backspin, and SYS 96-1 to fall below the expected industry standard of 6.5.

2001

The 2001 growing season was unseasonably warm at its onset, and a greater than normal array of diseases plagued the bentgrass turf plots. The best of these bentgrass cultivars appeared unaffected by the majority of these pests, and quality scores were extremely high for two velvet bengrasses: Vesper and SR 7200. These two grasses also had the highest genetic color scores and were the finest in blade width (Table 3), thus retaining the high level of excellence noted in the previous growing season. Excellent quality was also observed in those grasses scoring from 6.9 to 7.3; and ranked in descending order as follows: SYN 96-3, SYN 96-2, SRX 1NJH, and ISI AP-5. There were no significant differences between the remaining grasses receiving scores of 6.5 and above. Only BAR CB 8US3, Penncross, and Providence had low quality scores.

Two mid-summer but mild Pythium infections served to limit quality scores in these three susceptible grasses. Because the turf plot area is long and aligned across the slope, not all of the other grasses or their replicates were challenged equally by Pythium. When supplemental irrigation was applied, however, ample zoospore spread served to test most of the grasses represented here. In the case of BAR CB 8US3, Penncross, and Providence, extreme turf loss in one or more replicates served to greatly depress both turf quality and color scores. Other grasses faired better when faced with a mild mid-summer infection period of very short duration. Little or no effect of Pythium was seen in plots of Vesper, SR 7200, Syn 96-3, Syn 96-2, or Syn 96-1. Additionally, PENNG-6 and PENN G-1 were able to

Table 2. Turfgrass quality, genetic color and fall cover ratings for bentgrass varieties seeded in May 1999 at the University of Maine. Means are the average of monthly ratings made during the 2000 growing season.

Variety	Quality[1]	Genetic Color[2]	Fall Cover
1 VESPER	8.7	9.0	93
2. SR 7200	8.4	9.0	90
3. SRX 1NJH	7.3	8.7	90
4. SRX 1BPAA	7.1	9.0	90
5. PST-A2E	7.0	7.3	92
6. ABT-CRB-1	7.0	8.0	90
7. PENN A-1	6.9	7.0	88
8. BENGAL	6.9	6.7	92
9. SYN 96-3	6.9	6.7	80
10. SYN 96-2	6.8	7.3	85
11. PENN G-6	6.8	7.7	88
12. PENN G-1	6.8	8.0	80
13. PICK CB 13-94	6.7	7.3	85
14. CRENSHAW	6.7	7.7	77
15. PENN A-2	6.7	7.3	78
16. SYN 96-1	6.7	6.3	77
17. PENN A-4	6.6	8.0	78
18. SR 1119	6.6	7.7	80
19. ISI AP-5	6.5	8.7	82
20. BRIGHTON	6.4	7.7	82
21. L-93	6.4	7.7	87
22. CENTURY	6.3	7.3	85
23. BACKSPIN	6.3	6.3	87
24. IMPERIAL	6.3	7.0	80
25. PROVIDENCE	6.2	7.3	88
26. BAR CB 8US3	6.2	7.7	77
27. PENNCROSS	6.1	7.3	82
28. PENNLINKS	5.9	7.3	83
29. BAVARIA	4.8	5.0	83

[1]Varieties with quality ratings of 8.4 or higher did not differ from one another. Those varieties with ratings of 7.3 to 6.8 did not differ from one another, but were significantly lower than those over 8.4

[2]Varieties with color ratings over 8.0 did not differ from one another, but were significantly higher than those rated lower.

maintain excellent color despite the mild Pythium infection. Turf managers using this information should be cautioned that Pythiuim rarely occurs at the University of Maine, hence better Pythium tolerance and resistance data could be found from NTEP testing sites in Pennsylvania, Maryland, and New Jersey.

During 2001, only Vesper was able to maintain the extraordinary color observed the previous season. There was no significant difference, however, between Vesper and SR7000 and both appeared to be very dark and uniform in coloration throughout the 2001 growing season. Excellent color was also noted for the SYN series and with SRX 1BPAA, PENN G-6, G-1, and A-1. Moderate to acceptable genetic color scores were seen for all other grasses with the exception of Pennlinks, PENN A-2, Imperial, and BAR CB 8US3. Turf managers must remember that the velvet bentgrasses require far less nitrogen fertilizer than do other bents and, in fact, respond poorly to its application. The high rate of nitrogen used in this test may have compromised these velvet bentgrasses; however, their continued strength in quality would appear to counter that claim.

Leaf texture data appeared consistent from 2000 to 2001 with the velvet bentgrasses demonstrating far more fine or needle-like texture that the other bentgrasses. Again, the most dramatic scores for texture are seen with Bavaria (9.0), Vesper (8.7), and to a slightly lesser extent, SR 7200 (8.0). None of the remaining bentgrasses could be called “fine” during their third year. This echoes complaints made by golf course superintendents from Cape Cod to Maine when they remark that bentgrasses often “coarsen-up” and become wide and flat bladed after several years. These wide blades are easily damaged by both mowing and golf action; they tend to wilt and spike up more readily and provide a difficult surface to play on or repair. Of the grasses tested here, none

Table 3. Turfgrass quality and genetic color for bentgrass varieties seeded in May 1999 at the University of Maine. Means are the average of monthly ratings made during the 2001 growing season.

Variety	Quality[1]	Genetic Color[2]	Leaf Texture[3]
1. VESPER	8.8	8.0	8.7
2. SR 7200	8.6	7.7	8.0
3. SYN 96-3	7.3	6.7	6.0
4. SYN 96-2	7.2	6.7	6.0
5. SRX 1NJH	7.1	6.7	5.3
6. ISI AP-5	6.9	6.7	5.7
7. SYN 96-1	6.8	7.0	6.0
8. SRX 1BPAA	6.8	6.7	5.3
9. ABT-CRB-1	6.8	6.3	6.3
10. PENN G-6	6.8	7.0	5.3
11. L-93	6.8	6.7	5.3
12. PST-A2E	6.8	6.3	6.3
13. CENTURY	6.8	6.0	5.7
14. PICK CB 13-94	6.8	6.0	4.7
15. BENGAL	6.7	6.3	6.0
16. PENN G-1	6.7	7.0	6.0
17. SR 1119	6.7	6.3	5.3
18. PENN A-1	6.7	6.3	5.7
19. BACKSPIN	6.5	6.3	5.7
20. PENNLINKS	6.4	5.3	5.3
21. IMPERIAL	6.4	5.7	5.0
22. CRENSHAW	6.4	6.0	6.0
23. PENN A-4	6.4	7.3	6.0
24. BRIGHTON	6.4	6.3	5.0
25. PENN A-2	6.3	5.7	5.0
26. BAVARIA	6.1	6.3	9.0
27. BAR CB 8US3	6.0	5.7	6.0
28. PENNCROSS	5.9	6.3	5.7
29. PROVIDENCE	5.9	6.0	5.3

[1]Varieties with quality ratings of 8.6 and higher were not significantly different from one another. They were, however, significantly higher than those rated from 7.3 to 6.9. which did not differ from one another.
[2]Varieties with genetic color ratings of 6.3 and higher were not significantly different.
[3]Varieties with leaf texture ratings of 8 to 9 were significantly finer than the others.

of them, save the velvet bentgrasses, scored a 7.0 for fine leaf texture in the third year, and all of them showed evidence of this coarsening phenomenon. Those whose leaf texture makes them inadvisable for selection include Providence (formerly very fine but coarsening badly in this year of the trial), PENN A-2, Brighton, Imperial, Penncross, Pennlinks, SR 1119, L-93, PENN G-6, and SRX 1NJH.

2002

The winter of 2001–2002 was severe, but usually provided adequate to full snow protection for the grasses in this trial. When visible, winter color was unchanged from previous years and winter dessication was not observed. Prophylatic application of pink and gray snow mold fungicides provided some protection, but pink snow mold, causal agent *Microdochium nivale,* infected nearly all cultivars to some degree. Infection centers were counted and percentage of infection in square feet computed when evaluated in May (Table 4). The velvet bentgrasses Vesper, Bavaria, and SR 7200 were nearly free from infection, and this apparent resistance to this ubiquitous pathogen may prove valuable to golf course and fine turf managers in Maine and the Maritime Provinces. Seven of the nine replicate plots for these three cultivars were free of both winter and spring snow mold infection while infection in the remaining replicates of these cultivars was less than 5%. In contrast, the most of the other bentgrasses were infected at 45% to 95% levels and suffered severe compromises to turf health. As a result, in some of these grass cultivars, the long times required for growing out of this compromised state were responsible for the depression of turf grass quality scores as late as July.

Table 4. Turfgrass quality for bentgrass varieties seeded in May 1999 at the University of Maine. Means are the average of monthly ratings made during the 2002 growing season.

Variety	Quality[1]	Color[2]	Pink Snow Mold[3]
1. VESPER	8.9	9.0	4.0
2. SR 7200	8.6	9.0	2.0
3. ISI AP-5	7.2	8.0	4.0
4. BRIGHTON	7.2	8.0	3.0
5. SRX 1BPAA	7.1	7.7	4.3
6. PENN G-1	7.1	6.7	3.3
7. CENTURY	7.0	7.7	2.7
8. PENN A-1	7.0	6.3	5.0
9. BACKSPIN	7.0	8.0	1.7
10. PENN A-4	7.0	7.0	4.3
11. PENNLINKS	7.0	7.7	4.0
12. SR 1119	7.0	7.7	3.0
13. SRX 1NJH	6.9	7.3	5.0
14. PENNCROSS	6.8	7.7	1.7
15. PICK CB 13-94	6.8	7.7	1.7
16. BENGAL	6.7	7.3	2.7
17. SYN 96-2	6.7	7.0	1.3
18. PROVIDENCE	6.7	7.7	3.0
19. SYN 96-1	6.7	7.3	1.7
20. ABT-CRB-1	6.6	6.3	3.3
21. L-93	6.6	7.3	4.0
22. PENN G-6	6.6	7.3	6.3
23. BAR CB 8US3	6.5	7.3	2.0
24. CRENSHAW	6.5	7.3	2.0
25. BAVARIA	6.4	7.3	3.7
26. PST-A2E	6.3	6.3	6.3
27. PENN A-2	6.3	7.7	4.7
28. IMPERIAL	6.2	7.0	3.3
29. SYN 96-3	6.2	7.3	4.0

[1]Varieties with a quality rating of 8.5 or higher were significantly different from all others.
[2]Varieties with color ratings of 8.0 or higher did not differ from one another, but were significantly higher than the others.
[3]Varieties with snow mold ratings over 5.0 suffered significantly less damage than all others.

Once into the warm temperatures of spring and summer, the velvet bentgrasses again demonstrated extremely high quality scores (Table 4). Initial decreases in mowing height acted to improve bentgrass quality by reducing the formation of aerial crowns and by removing laid-over leaf tissue. Vesper averaged 8.9 when at least two of its replicates scored a perfect 9.0 on all testing dates. SR 7200 also exhibited extraordinary high quality in 2002, averaging scores of 8.6 across all replicates. Ten of these grasses averaged 7.0 or above; these included ISI AP-5, Brightlon, SRX 1BPAA, PENN G-1, Century, PENN A-1, Backspin, PENN A-4, Pennlinks, and SR 1119. Additionally, 22 of the 29 cultivars tested here scored above the industry standard of 6.5. Of the remaining seven grasses, only Bavaria, PST-A2E, PENN A-2, Imperial, and SYN 96-3 demonstrated slightly less acceptable quality.

Turfgrass color was also extremely good in 2002. Both Vesper and SR 7200 scored a perfect 9.0 for each testing date in 2002. Such extraordinary color accompanied by extremely fine leaf texture makes these two cultivars excellent candidates for use in Maine. However, their use will require a considerable adjustment in agronomic techniques by turf managers in order to fulfill the potential they demonstrated in this trial. Excellent (8.0) and improving color was also achieved by ISI AP-5, Brighton, and Backspin, while 20 other cultivars scored above 7.0 for this parameter. Even Providence, Pennlinks, and Penncross, which had fared poorly in earlier years, had some color improvement. Of the few that fell below 7.0, PENN A-1, ABT-CRB-1, and PST-A2E showed color consistent with the previous years' data.

Disease data were difficult to obtain in 2002 despite nearly 30 days when temperatures exceeded 90°F. Brown patch, leaf spot, and occasional anthrac-

nose made sporadic appearances in these turf plots, but data were sufficiently inconsistent to present. The green cutworm showed some sporadic preference for some cultivars over others, but again these data were plagued by inconsistencies.

Four Year Averages

The two improved velvet bentgtrasses Vesper and SR 7200 were characterized by extremely high turfgrass quality ratings. During the four-year evaluation period, both averaged greater than 8.0 in overall quality, which was significantly greater than the other bentgrasses in the test (Table 5). Managers should remember, however, that fineness of leaf texture and exceptionally deep coloration are major components of turfgrass quality measurements. When these attributes are accompanied by excellent tolerance to mowing, these grasses exhibited excellent quality scores.

Three other bentgrasses, SRX 1NJH, ABT-CRB-1, and SRX 1BPAA, also performed well. These grasses showed excellent promise for use in Maine, but do not possess the fine leaf texture or the extreme tolerance to pink snow mold noted for the two velvet bentgrasses. Fifteen other bentgrassess were not significantly different from these three despite slightly lower quality scores. This group includes the SYN series, three of the PENN series, entries from companies such as Barenburg, Pickseed West and Pure Seed testing, and the cultivars Century and Crenshaw. Those cultivars falling below industry expectations in this test included such standards as Providence, Penncross, Pennlinks, L-93, and PENN A-2. Two new colonial bentgrasses, Imperial and Bavaria, performed poorly in this test, primarily because of crowning up, accompanied by a rapid growth rate that left them looking "weedy" despite a finer leaf texture than normally seen in colonial bentgrasses.

Excellent color was exhibited by the velvet bentgrasses throughout this trial. They were always darker and more consistent in coloration than were the creeping or colonial types. Color scores for the velvets approached or achieved perfection at some point in each and every year. In cooler seasons, scores as high as permitted, 9.0, were noted. The four-year average for Vesper was 8.0 while three other grasses (SR 7200, SRX 1BPAA and ISI AP-5) averaged 7.8. SRX 1NJH was statistically indistinguishable from these as were 15 other grasses including Brighton, PENN G-1, G-6, and Century. Improvements noted in color and leaf texture increase the choices available to turfgrass managers and will allow them some freedom when seed availability may be restricted by yield and/or price. Managers should note that bentgrass mixtures were not seeded in this trial, and data on plot spread or aggressiveness were not recorded during this trial. The problematic diseases observed during the course of this test are noted in Table 5. Dollar spot (*Sclerotinia homoeocarpa*) was observed and the damage evaluated in the years 2000, 2001, and 2002. The Dollar spot data represent the mean evaluation for the three years. Vesper and SR 7200 velvet bentgrasses demonstrated the greatest tolerance to this organism, with ratings over 8.0. All other cultivars, except PICK CB 13-94, Pennlinks and BAR CB 8US3, which showed susceptibility to Dollar spot, had scores between 7.0 and 7.9. Brown patch (*Rhizoctonia solani*) infestations were noted in 2000 and 2001 and again the velvet bents, Vesper and SR7200 were the varieties which were least affected by this organism. All other bentgrass varieties produced scores of 6s and 7s, indicating some damage. Varieties such as Century, Brighton, Pennlinks, BAR CB 8US3, Providence and Bavaria had scores of less than 6.0, indicating considerable lack of tolerance to the Brown patch organism.

Leaf blade texture will constitute one of the advantages of using velvet bentgrasses for putting and bowling surfaces in Maine. But the very fine texture of these grasses is more normally accompanied by slow recovery rates and a gradual thinning during periods of summer stress. These problems were not encountered in this test in part because of the height of cut, relative infrequency of mowing, and the lack of foot and machine traffic. Ideally this test should be repeated at an actual golf or bowling facility so that the effects of these additional stresses could be evaluated. Pending that development, we hope to repeat part or this entire test with particular reference to disease tolerance or resistance and changes in texture and leaf and crown morphology over time. Development of grain from mowing, spiking up from putting practices, invasive or aggressive rate of spread or disease dissemination across plots were not evaluated as well. Furthermore, we were unable to pinpoint insect/host relationships although the green cutworm injury data suggests some unusual specificity.

Table 5. Turfgrass quality, genetic color and disease ratings for bentgrass varieties evaluated at the Littlefield Ornamentals Trial Garden at the University of Maine. Means are the average of monthly ratings made over the four-year duration of the study (1999-2002).

Rank	Variety	Quality[1]	Genetic Color[2]	Dollar Spot[3]	Brown Patch[4]
1.	VESPER	8.5	8.0	8.6	9.0
2.	SR 7200	8.2	7.8	8.4	8.9
3.	SRX 1NJH	7.1	7.6	7.8	7.3
4.	ABT-CRB-1	6.9	7.0	7.3	7.3
5.	SRX 1BPAA	6.9	7.8	7.9	6.6
6.	PENN A-1	6.8	6.8	7.9	7.5
7.	ISI AP-5	6.8	7.8	7.1	6.4
8.	SYN 96-2	6.8	7.2	7.7	7.6
9.	SYN 96-3	6.8	7.1	7.0	7.3
10.	PENN G-1	6.8	7.3	7.2	7.1
11.	CENTURY	6.8	7.3	7.1	5.7
12.	BENGAL	6.8	7.1	7.6	6.7
13.	BRIGHTON	6.7	7.4	7.4	5.6
14.	SYN 96-1	6.7	7.0	7.0	6.8
15.	PENN G-6	6.7	7.3	7.7	7.4
16.	PST-A2E	6.7	6.8	7.4	6.8
17.	SR 1119	6.7	7.3	7.3	6.5
18.	PICK CB 13-94	6.7	7.3	6.2	6.5
19.	PENN A-4	6.7	7.3	7.4	6.7
20.	CRENSHAW	6.7	7.3	7.2	6.8
21.	L-93	6.6	7.3	7.0	6.2
22.	BACKSPIN	6.5	6.8	7.2	6.5
23.	PENNLINKS	6.5	7.2	6.9	5.9
24.	PENN A-2	6.5	7.1	7.0	6.0
25.	IMPERIAL	6.4	6.8	7.3	6.0
26.	BAR CB 8US3	6.3	7.1	6.0	5.1
27.	PROVIDENCE	6.3	7.0	7.0	4.8
28.	PENNCROSS	6.3	7.3	7.4	7.2
29.	BAVARIA	5.9	6.0	7.6	5.2

[1]Varieties with turf quality ratings of 6.7 to 7.1 were not significantly different. They were, however, significantly lower than those varieties with ratings of 8.2 and higher.
[2]Varieties with genetic colors ratings of 7.1 or higher were not significantly different.
[3]Varieties with disease ratings of 8.4 and above suffered significantly less damage than did all other varieties, which did not differ from one another.
[4]Varieties with disease ratings of 8.9 and higher suffered significantly less damage than all other varieties, which did not differ from one another.

CONCLUSIONS

After a four-year evaluation period, it became apparent that the velvet bentgrass varieties Vesper and SR 7200 were the outstanding performers under the conditions imposed at the Littlefield Garden located at the University of Maine. These varieties consistently ranked first in quality and color and demonstrated excellent tolerance to the Dollar spot and Brown patch organisms that infected the bentgrass varieties in this study. As a cautionary note, however, any turf manager contemplating using these velvet varieties should be aware that their use will entail employing more exacting management techniques to ensure that their superior performance is maintained. Creeping bent varieties such as SRX 1NJH and ABT-CRB-1 also produced excellent quality scores, but did not possess the fine leaf texture or disease tolerance observed for the velvets. Several of these highly rated cultivars produced very good quality scores, which should make them possible options for managers wishing to try new varieties here in Maine. Creeping bent varieties, such as Providence, Penncross, and BAR CB 8US3 failed to produce the quality turf anticipated and based upon the conditions under which they were evaluated, should be considered as distant alternative choices. The colonial bent varieties Imperial and Bavaria failed to produce quality turf under our management system.

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